Progress in understanding the causes of the RICH fire

Andre Lebedev, Holger Meyer, Rajendran Raja
21-Apre-2004

In this document we detail our current understanding of the causes of the MIPP RICH fire of 14 March 2004. We investigate two mechanisms for ignition. The first is due to repeated sparking in the phototube and the second due to shorting out of the resistor chain in the pmt base.

The Hamamatsu bases were not found to be flammable in Jim Priest's tests .
So we must assume the fire must have started in an FEU-60 base. The pattern of fire is consistent with it being centered in column 73, which was an FEU-60 column.

Repeated Sparking in a phototube

We managed to isolate a tube in column 89B (tube 16) that was known to spark. We observed this tube to spark at a frequency of ~5Hz while emitting a pinkish light.. The voltage at which the sparks occurred was measured to be ~ 1000V. The spark was found to occur somewhere near junction between the glass base of the pmt and the pmt electronic base. It was not clear whether the light was being emitted from inside the tube or from outside the tube between the wires coming out of the tube. Associated with the tube spark, there was a spark at the readout cable end to complete the circuit. This indicated that the spar was occurring between one of the dynodes and the anode. A movie of this sparking has been made. As the sparking tests continued the frequency of sparks decreased (to 1 every 10 seconds), the voltage at which the sparking occurred increased to 1500Volts and the color of the spark changed from pink to blue.
The amount of energy associated with a blue spark was estimated to be ~50 millijoules, with a peak current of ~ 4A and a duration of ~50microseconds. The blue spark was indeed verified to be occurring within the tube volume not in the base. The total energy of such a spark in MIPP would certainly exceed 50millijoules, since the charge stored in the cables of nearby tubes would also participate in such a spark.

Interpretation:- All sparking occurs with the pmt tube, not outside where it can ignite the sleeve. As the tube fails, it lets in more and more air. When the vacuum is reasonably good, it is easier to cause a spark and we get the Crookes' type discharge with emissions in the pink. As more air gets in, the sparks get harder, more voltage is needed and the spark color is blue. Since the blue spark is definitely in the tuibe volume, the pink sparking should also be in the same location, since the pink sparking should still continue outside the tube if it is located outside.

Conclusion:- Tube sparking is unlikely to have caused the fire.

Shorting of the resistor chain in the FEU-60 base

In order to test this hypothesis, we measured a single resistor in the base to be 1Megaohm and applied HV to it. A movie of this has been made. When a voltage of 1500V was applied to this resistor, a very energetic spark was emitted. The resistor retained its integrity for a couple more such assaults before displaying a lower resistance of ~15KiloOhms.

Interpretation:- If such sparks occur in the base, they may cause the flammable covering to ignite since the flammable covering is in direct contact with the resistors. There are intermediate scenarios where all but 2 resistors are shorted, which can result in a gradual heating of the base eventually leading to ignition. This also needs further experimentation.

Conclusion:- The shorting of the base is a more likely explanation of the fire. The shorting could have occurred due to frayed insulation on wires in the FEU-60 bases and or exposed wire segments near solder joints. Such a short would not cause the HV power supplies to trip, since the excess amount of current drawn would be ~ 2mA. Further tests (perhaps attempting to ignite a sleeve using this mechanism) may shed more light on what actually happened. The panel recommendations guard against either possibility being the cause.